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FINAL PROGRESS REPORT FOR U.S.D.A.

COST-REIMBURSEMENT CONTRACT NO. 12-14-100-8903(73)

B

Title: Investigations of thermal characteristics of meat and of related reactions of meat constituents. X S-227.

Location: New York (Cornell).

Personnel: Cornell - Dr. G.H. Wellington - Leader, Dr. J.W. Sherbon and Dr. J.R. Stouffer.

U.S.D.A. - Mr. Clifton E. Swift, Research Chemist, Eastern Utilization Research and Development Division, Agricultural Research Service, Wyndmoor, Pennsylvania.

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Date Initiated: July 1, 1966.

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Date of Termination: June 30, 1970.

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General Objectives and Accomplishments

The general objectives of this research included the establishment of more reliable methods for the commercial heat processing of meat and meat products. It was the belief of the project leaders that improvement in processing methods could develop from more complete knowledge of the character of the meat components and the behavior of the components under heat treatments. Within the general objectives, experiments and observations were organized under the following four distinct areas of research activities.

Area 1. The role of the connective tissue complex in meat toughness: Newborn veal, 11½-month-old steers, 14½-month-old heifers and 9 to 10½-year-old cows were used to identify the polysaccharide types present in the epimysium and to determine the relationship between the amount of connective tissue polysaccharides and the amount of collagen in the epimysium. Trimmed muscle was used for tenderness evaluation by shear force. Average amounts of 332, 247, 230 and 202 mg dry polysaccharides per 100 g dry, defatted epimysium were isolated from the veal, steer, heifer and cow groups respectively. A negative correlation was obtained between age of animals and amount of isolated polysaccharides. Twenty per cent of the hexosamine present before the extraction was found in the isolated polysaccharides. Using Dowex 1 X-2 chromatography, an average of 42% of the total uronic acids of the veal and heifer groups were found to be eluted with 0.5 M NaCl. In the veal and heifer groups, 37% and 38% of the total uronic acids were eluted with 1.5 M NaCl, while in the cow and steer groups, the amounts represented 71% and 70%. The percentages of uronic acids eluted with 2.0 M NaCl were 20%, 11%, 19% and 12% in the case of the veal, steer, heifer and cow groups, respectively. Dermatan sulfate was found to be the main polysaccharide eluted with 1.5 M NaCl for the veal, heifers and cows. It also represented an important type in the steers, although other sulfated polysaccharides seemed to be present. Cellulose polyacetate electrophoresis confirmed that hyaluronic acid and dermatan sulfate were present in the epimysium. The ratio of hexosamine to insoluble collagen in the epimysium was positively associated with muscle tenderness.

Publications of these results are indicated in Table 1. under Cormier.

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Area 2. The composition of institutional beef cuts:

The proximate composition of physically separated tissue components from oven prepared beef ribs (National Meat Purveyors Item No. 107) in ribs selected for different levels of marbling was studied in detail. In general, the composition of the physically separable components seemed to be very much the same in rib roasts from right and left sides. The significant differences in composition, when they were found, seemed to occur mainly in the fatty tissue components. These data supported the conclusion that lean tissue of similar muscles from either side of an animal will have similar cooking properties. Verification of this relationship is essential for acceptable experimental designs for the measurement of differences due to heat treatments on institutional meat cuts. The detailed analytical values and the statistical analysis of composition differences are in the Ph. D. Thesis of Dr. Eini Laakkonen as listed in Table 1.

Area 3. Applications of long period, low temperature schedules for meat cooking and of short period cooking schedules: The extensive studies of Dr. Eini Laakkonen resulted in several publications as listed in Table 1. The most exciting data indicated that with long time low temperature heating below 60C (140F) there is a drastic reduction of toughness between the 4th and the 5th hours of heating. Dr. Laakkonen determined for the first time that this decrease in toughness is apparently associated with the presence of naturally occurring collagenolytic enzymes in the meat. These enzymes soften the collagenous connective tissue by hydrolysis during low temperature cooking.

Mr. Richard J. DeRisio conducted a series of experiments designed to contrast the effects of low-temperature heating of beef short loin strip steaks at 250 F with high-temperature convection oven heating at 450 F. The final analysis of these data is nearing completion in the DeRisio M. S. Thesis. Low temperature resulted in less weight loss on cooking. Slower cooking produced more tender loin steaks in most instances but the final statistical significance of these experiments awaits complete analysis. The high temperature, forced air convection oven reduced the cooking time to $\frac{1}{2}$ or less of the time required for cooking at the lower temperature to the same final internal meat temperature.

Experiments were conducted by DeRisio to determine whether or not the level of alkaline phosphatase enzyme activity in a meat product following commercial cooking is related to the maximum temperature of cooking. The significance of these experiments, their possible application in meat processing control and in the enforcement of specified heating schedules were reported in the 6th Semi-annual Progress Report Jan.-June 1969, pages 3 and 4. The final report of the success of these experiments and the reliability of the test will be in the DeRisio Thesis.

Area 4. The thermal properties of meat:

Mr. Jesus Melgar, under the supervision of Dr. John W. Sherbon, reviewed the theoretical considerations of the thermal properties of meat and designed original equipment for the measurement of the thermal conductivity of meat. This modified parallel plate thermal conductivity instrument was tested with beef muscle samples. The experimental thermal conductivity values observed were all higher than published values measured at lower temperatures.

It was concluded that the equipment designed and used under this contract was suitable for the measurement of meat thermal conductivity at any temperature above room temperature.. The values for conductivity are in the Melgar M. S. Thesis.

Table 1. Research supported by U.S.D.A. Contract No. 12-14-100-8903(73) funds and conducted largely by Cornell University Graduate Candidates for degrees in the Graduate Field of Food Science and Technology.

STUDENT AUTHOR	DEGREE	RESEARCH PUBLICATIONS
Laakkonen, Eini	Ph. D.	Laakkonen, E. 1969. Collagenolytic activity and water-holding capacity as factors affecting tenderness during low-temperature long-time heating of bovine muscle. Cornell University. Ph. D. Thesis. University Microfilms, Ann Arbor, Michigan. 214 p.
		Laakkonen, E., G.H. Wellington and J.W. Sherbon. 1970. Low temperature long time heating of bovine muscle. I. Changes in tenderness, water binding capacity, pH, and amount of water soluble components. J. Food Sci. (In press for March-April issue)
		Laakkonen, E., J.W. Sherbon and G.H. Wellington. 1970. Low temperature long time heating of bovine muscle. II. Changes in electrophoretic patterns. J. Food Sci. (In press for March-April issue)
		Laakkonen, E., J.W. Sherbon and G.H. Wellington. 1970. Low temperature long time heating of bovine muscle. III Collagenolytic activity. (In press for March-April issue) J. Food Sci.
		Laakkonen, E., G.H. Wellington and J.W. Sherbon. 1969. Tenderness of beef as affected by the age of animal. J. Sci. Agr. Soc. Finland 41: 143-148.
		Laakkonen, E., G.H. Wellington and J.W. Sherbon. 1970. Low temperature long time heating of bovine muscle. I. Changes in tenderness, water binding capacity, pH, and the amount of water soluable components. II. Changes in electrophoretic patterns. III. Collagenolytic activity. (Abstract). Proc. Amer. Meat Sci. Ass. 22:191-193.
		Laakkonen, E., G.H. Wellington and J.W. Sherbon. 1969. Tenderizing effect of low-temperature long time heating of bovine muscle. Proc. European Meeting of Meat Research Workers. 15:296-301.

- Cormier, Auréa Ph. D. Cormier, Auréa. 1969. Connective tissue polysaccharides of bovine semimembranosus muscle and alterations in their type with age. Cornell University. Ph. D. Thesis. University Microfilms, Ann Arbor, Michigan. 104 p.
- Cormier, A., G.H. Wellington and J.W. Sherbon. 1970. Epimysial connective tissue polysaccharides of bovine semimembranosus muscle and alterations in their type with age and sex differences. (Twenty-four page manuscript submitted to J. Food Sci. June 12, 1970).
- McGar, Jesus V. M.S. The measurement of thermal conductivity of meat. Cornell University M.S. Thesis. Cornell University Library. 44p.
- DeResio, Richard M.S. Partially completed M.S. Thesis reporting effects of slow and rapid cooking of beef and the level of phosphatase activity surviving the commercial processing of meat products. To be available from Cornell University Library Fall 1970.

Uncompleted activities under the project on June 30, 1970

1. The extensive manuscript by Sister A. Cormier, Ph. D., and submitted to Journal Food Science will be carried through the final steps of publication.
2. A manuscript covering the experiments of Mr. Jesus V. Melgar is under preparation by Dr. J.W. Sherbon. Even though Dr. Sherbon is on a 12 month sabbatical leave effective July 1970, plans have been made for the completion of this manuscript and its submission for publication.
3. The M. S. Thesis of Mr. Richard DeRisio is nearing final form. Two publications are possible and are anticipated from the experiments by Mr. DeRisio and the project leaders:
 - a. The influences of slow and rapid cooking on beef strip loin steaks cooked with commercial equipment
 - b. The development of an alkaline phosphatase test for the verification of the level of prior heat processing of comminuted meat products

